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May 9, 2022

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Seattle, WA 98101-3927

Re: *Brad Norman vs. Travelers Indemnity Company*
ARCCA Case No.: 3601-026
Case No.: 20-2-10988-6 SEA

Dear Ms. Bamberger:

Thank you for the opportunity to participate in the above-referenced matter. Your firm retained ARCCA, Incorporated to evaluate the subject incident in relation to the forces and claimed biomechanical failures involved in the incident of Mr. Brad Norman. This analysis is based on information currently available to ARCCA. However, ARCCA reserves the right to supplement or revise this report if additional information becomes available to us.

The opinions given in this report are based on my analysis of the materials available, using scientific and biomechanical methodologies generally accepted in the automotive industry.[1,2,3,4,5] The opinions are also based on my education, background, knowledge, and experience in the fields of human kinematics and biomechanics. I have a Bachelor of Science degree in Mechanical Engineering, a Master of Science degree in Biomedical Engineering, and have completed the educational requirements for my Doctor of Philosophy degree in Biomedical Engineering. I am a member of the Society of Automotive Engineers, the Association for the Advancement of Automotive Medicine, the American Society of Safety Engineers, and the American Society of Mechanical Engineers.

I have designed, developed, and tested kinematic models of the human cervical spine and head. My testing and research have been performed with both anthropomorphic test devices and human subjects. As such, I am very familiar with the theory and application of human tolerance to inertial and impact loading, as well as the techniques and processes for evaluating human kinematics and biomechanical failure potential.

I have designed, developed, and tested seating and restraint systems. I performed my testing and research with both anthropomorphic test devices and human subjects. As such, I am very familiar with the theory and application of restraint systems and their ability to protect occupants from

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1 Nahum, A.M., & Gomez, M.A. (1994). *Injury Reconstruction: The Biomechanical Analysis of Accidental Injury* (No. 940568). SAE Technical Paper.

2 Siegmund, G., King, D., Montgomery, D. (1996). *Using Barrier Impact Data to Determine Speed Change in Aligned, Low-Speed Vehicle-to-Vehicle Collisions* (No. 960887). SAE Technical Paper.

3 Robbins, D.H., Melvin, J.W., Huelke, D.F., & Sherman, H.W. (1983). *Biomechanical accident investigation methodology using analytical techniques* (No. SAE 831609). SAE Technical Paper.

4 King, A.I. (2000). Fundamentals of Impact Biomechanics: Part I-Biomechanics of the Head, Neck, and Thorax. *Annual Review of Biomedical Engineering*, *2*(1), 55-81.

5 King, A.I. (2001). Fundamentals of Impact Biomechanics: Part II-Biomechanics of the Abdomen, Pelvis, and Lower Extremities." *Annual Review of Biomedical Engineering*, *3*(1), 27-55.

inertial and impact loading, as well as the techniques and processes for evaluating their performance and biomechanical failure potential.

Incident Description:

According to the available documents, on February 3, 2017, Mr. Brad Norman was the belted driver of a 1989 Chevrolet C2500 traveling eastbound on Highway 101 in Port Angeles, Washington. Mr. Eric Weikal was the belted front passenger in the subject Chevrolet. Ms. Linda Huard-Hoffman was the driver of a 2012 Jeep Liberty traveling westbound on Hwy 101. When the incident Jeep crossed into the oncoming travel lane, the front of the subject Chevrolet contacted the right side of the incident Jeep.

On August 28, 2017, Mr. Norman was helping drive posts when a 20 pound metal post driver fell approximately 8 feet and contacted the top of his head.

Information Reviewed:

In the course of my analysis, I reviewed the following materials:

- Department of the Interior Investigation's Traffic Crash Report, case no. NP17010994
- IMARS Incident Details for case no. NP17010994
- Twelve (12) photographic reproductions of the scene
- Nineteen (19) photographic reproductions of the subject 1989 Chevrolet C2500
- Twelve (12) photographic reproductions of the incident 2012 Jeep Liberty
- Complaint, Brad Norman vs. Travelers Indemnity Company, no. 20-2-10988-6 SEA, July 9, 2020
- Travelers' First Interrogatories and Requests for Production of Documents to Plaintiff and Answers Thereto, Brad Norman vs. Travelers Indemnity Company, no. 2:20-CV-01250-JCC, November 15, 2021
- Deposition Transcript of Brad Norman, September 24, 2019
- Deposition Transcript of Brad Norman with exhibits, April 19, 2022
- Medical Records pertaining to Brad Norman
- VinLink data sheet for the subject 1989 Chevrolet C2500
- Expert AutoStats data sheets for a 1989 Chevrolet C2500
- VinLink data sheet for the incident 2012 Jeep Liberty
- Expert AutoStats data sheets for a 2012 Jeep Liberty
- Publicly available literature, including, but not limited to, the documents cited within the report, learned treatises, text books, and scientific standards

Biomechanical Analysis:

The method used to conduct a biomechanical analysis is well defined and accepted in the scientific community and is an established approach to assessing biomechanical failure causation as documented in the technical literature.[6,7,8,9,10] Within the context of this incident, my analyses consisted of the following steps:

1. Identify the biomechanical failures that Mr. Norman claims were caused by the subject incident on February 3, 2017;
2. Quantify the nature of the subject incident in terms of the forces, accelerations, and changes in velocity of the subject Chevrolet;
3. Determine Mr. Norman's kinematic response within the vehicle as a result of the subject incident;
4. Define the biomechanical failure mechanisms known to cause the reported biomechanical failures and determine whether the defined biomechanical failure mechanisms were created during the subject incident;
5. Evaluate Mr. Norman's personal tolerance in the context of his pre-incident condition to determine to a reasonable degree of scientific certainty whether a causal relationship exists between the subject incident and his reported biomechanical failures.

If the subject incident created the biomechanical failure mechanisms that generate the reported biomechanical failures, a causal link between the biomechanical failures and the event cannot be ruled out. If, the subject incident did not create the biomechanical failure mechanisms associated with the reported biomechanical failures, then a causal link to the subject incident cannot be established.

Biomechanical Failure Summary:

The available documents indicated Mr. Norman attributes post-concussion syndrome to the subject motor vehicle incident of February 3, 2017.

Damage and Incident Severity:

The severity of the incident was analyzed by using the available photographic reproductions and repair estimates of the subject Chevrolet and the incident Jeep in association with accepted scientific methodologies.[11,12] The police were called to the scene and took photographs of the scene and vehicles as part of their investigation (Figure 1). According to the police report, there was "*significant wet, heavy snowfall*" at the time of the subject incident. Photographs of the subject Chevrolet at the scene show the vehicle had toolboxes mounted on the truck bed, equipment in the

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6 Robbins, D.H., Melvin, J.W., Huelke, D.F., & Sherman, H.W. (1983). *Biomechanical accident investigation methodology using analytical techniques* (No. SAE 831609). SAE Technical Paper.

7 Nahum, A.M., & Gomez, M.A. (1994). *Injury Reconstruction: The Biomechanical Analysis of Accidental Injury* (No. 940568). SAE Technical Paper.

8 King, A.I. (2000). Fundamentals of Impact Biomechanics: Part I-Biomechanics of the Head, Neck, and Thorax. *Annual Review of Biomedical Engineering*, *2*(1), 55-81.

9 King, A.I. (2001). Fundamentals of Impact Biomechanics: Part II-Biomechanics of the Abdomen, Pelvis, and Lower Extremities." *Annual Review of Biomedical Engineering*, *3*(1), 27-55.

10 Whiting, W. C., & Zernicke, R. F. (2008). *Biomechanics of Musculoskeletal Injury*. Human Kinetics.

11 Siegmund, G.P., et al., (1996). Using Barrier Impact Data to Determine Speed Change in Aligned, Low-Speed Vehicle-to-Vehicle Collisions (SAE 960887). Warrendale, PA, Society of Automotive Engineers

12 Bailey, M.N., Wong, B.C., and Lawrence, J.M., (1995). Data and Methods for Estimating the Severity of Minor Impacts (SAE 950352). Warrendale, PA, Society of Automotive Engineers.

truck bed, and was towing a trailer filled with equipment. The narrative states "*Huard-Hoffman, driving [the incident Jeep], lost control and began to fishtail while traveling uphill. [The incident Jeep] crossed the center line and was headed into the ditch when [the subject Chevrolet] struck it on the passenger side*". The incident Jeep subsequently collided with the road's ditch. Combination airbag deployment was noted for the incident Jeep; the subject Chevrolet was not equipped with airbags. Both vehicles were towed from the scene.

Figure 1: Scene and vehicle photographs included in the Investigator's Traffic Crash Report

The photographs for the subject Chevrolet depicted damage to the front of the vehicle concentrated on the driver's side (Figure 2). The photographs for the incident Jeep showed primary damage to the passenger side between the wheels above the rocker panel (Figure 3).

Figure 2: Photographic reproductions of the subject 1989 Chevrolet C2500

Figure 3: Photographic reproductions of the incident 2012 Jeep Liberty

Energy-based crush analyses have been shown to represent valid and accurate methods for determining the severity of automobile collisions.[13,14,15,16,17] Analyses of the photograph and geometric measurements along with the repair record of the subject Chevrolet revealed the damage due to the subject incident. An energy crush analysis indicates that a single 32 mile-per-hour (mph) barrier impact to the front of an exemplar Chevrolet C2500 would result in significant and visibly noticeable crush across the subject Chevrolet's front structure, with a tapering residual crush of 0 to 42 inches (i.e., right to left of the subject Chevrolet's front).[18,19] For reference, the distance from the front bumper to the base of the windshield is 54 inches. Thus, 42 inches is well in excess of the crush in the subject incident. This analysis is for the vehicle alone. If an additional weight of 1,000 pounds is accounted for the speed decreases to 29 mph for 42 inches of crush. It is expected that the weight of the loaded trailer and truck bed would weigh in excess of 1,000 pounds. Therefore, the energy crush analysis shows the subject Chevrolet underwent a Delta-V (the Delta-V is the change in velocity of the vehicle from its pre-impact, initial velocity, to its post-impact

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13 Campbell, K.L. (1974). *Energy Basis for Collision Severity*. (No. 740565). SAE Technical Paper.

14 Day, T.D. and Siddall, D.E. (1996). *Validation of Several reconstruction and Simulation Models in the HVE Scientific Visualization Environment*. (No. 960891). SAE Technical Paper.

15 Day, T.D. and Hargens, R.L. (1985). *Differences Between EDCRASH and CRASH3*. (No. 850253). SAE Technical Paper.

16 Day, T.D. and Hargens, R.L. (1989). *Further Validation of EDCRASH Using the RICSAC Staged Collisions*. (No. 890740). SAE Technical Paper.

17 Day, T.D. and Hargens, R.L. (1987). *An Overview of the Way EDCRASH Computes Delta-V*. (No. 870045). SAE Technical Paper.

18 EDCRASH, Engineering Dynamics Corp.

19 PC-Crash Collision Software.

velocity) impact of less than 30 mph.[20] Using an acceleration pulse with the shape of a haversine and an impact duration of 100 milliseconds (ms), the average acceleration associated with a 30 mph impact is 13.7g.[21,22,23,24] By the laws of physics, the average acceleration experienced by the subject Chevrolet in which Mr. Norman was seated was less than 13.7g. [25,26] A similar crush analysis to the side of a Jeep Liberty confirms the change in velocity to the subject Chevrolet was less than 30 mph.[27,28]

The National Highway Traffic Safety Administration's (NHTSA) New Car Assessment Program (NCAP) is a series of crash tests in which new vehicles are tested and assessed on their crashworthiness and performance. Exemplar Chevrolet pickup trucks were tested in frontal impact tests at 30 to 35 mph.[29,30] The test Chevrolet pickups sustained approximately 22 to 30 inches of residual crush across their entire fronts (Figure 4). This is consistent with the analyses performed above quantifying the severity of the subject collision.

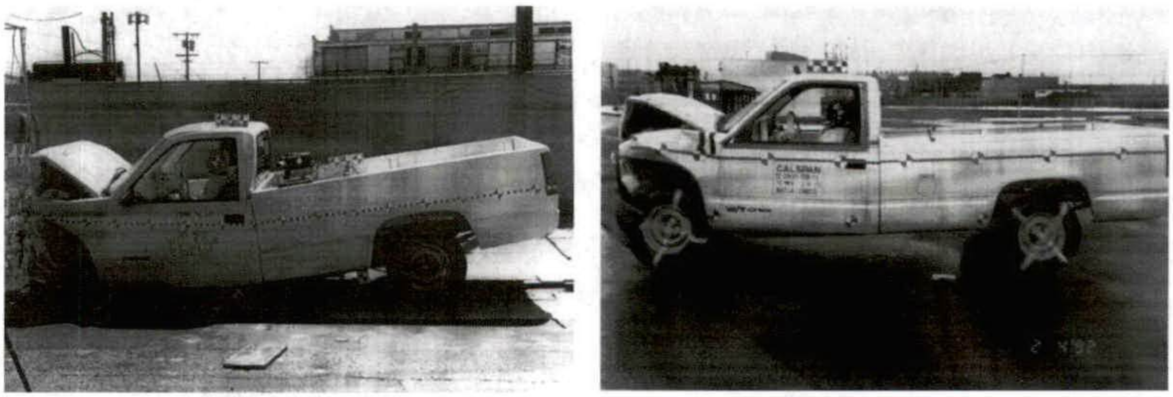

Figure 4: Photographic reproductions of the 1988 Chevrolet pickup (left) and 1992 Chevrolet pickup (right) involved in frontal barrier NHTSA tests

The National Automotive Sampling System (NASS) and Crash Investigation Sampling System (CISS) investigate real-world automotive collisions and collect the data for use by NHTSA. Below are photographic reproductions involving collisions with exemplar Chevrolet pickup trucks and Jeep Liberty's.[31,32] The post-impact damage from these real-world collisions was supportive of the conclusion that the subject Chevrolet experienced a frontal Delta-V of less than 30 mph (Figures

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20 Tumbas, N.S., Smith, R.A., (1988) Measuring Protocol for Quantifying Vehicle Damage from an Energy Basis Point of View, (SAE 880072). Warrendale, PA, Society of Automotive Engineers.

21 Agaram, V., et al. (2000). *Comparison of Frontal Crashes in Terms of Average Acceleration*. (No. 2000-01-0880). SAE Technical Paper.

22 Anderson, R.A., W.J.B., et al. (1998). *Effect of Braking on Human Occupant and Vehicle Kinematics in Low Speed Rear-end Collisions*. (No. 980298). SAE Technical Paper.

23 Tanner, B.C., Chen, F.H, Wiechel, J.F., et al. (1997). *Vehicle and Occupant Response in Heavy Truck to Car Low-Speed Rear Impacts*. (No. 970120). SAE Technical Paper.

24 Tanner, C.B., Wiechel, J.F., Bixel, R.A., and Cheng, P.H. (2001). *Coefficients of Restitution for Low and Moderate Speed Impacts with Non-Standard Impact Configurations*. (No. 2001-01-0891). SAE Technical Paper.

25 Siegmund, G.P., et al., (1996). *Using Barrier Impact Data to Determine Speed Change in Aligned, Low-Speed Vehicle-to-Vehicle Collisions*. (No. 960887). SAE Technical Paper.

26 Meriam, J.L., (1952). Mechanics Part II: Dynamics. John Wiley & Sons, New York.

27 EDCRASH, Engineering Dynamics Corp.

28 PC-Crash Collision Software.

29 National Highway Traffic Safety Administration New Car Assessment Program (NCAP) Frontal Barrier Impact Test. 1988 Chevrolet C1500 Pickup, Report No. MJ0100, March 31, 1988.

30 National Highway Traffic Safety Administration Vehicle Safety Compliance Testing for Occupant Crash Protection. 1992 Chevrolet Fleetside C1500 Pickup Truck, Report No. CN0112, February 4, 1992.

31 National Highway Traffic Safety Administration (NHTSA) Crash Viewer, NASS CDS (2004-2015) search.

32 National Highway Traffic Safety Administration (NHTSA) Crash Viewer, CISS Crash Viewer (Current) search.

5 to 8).

Figure 5: Photographic reproductions of a 1992 Chevrolet pickup truck involved in a front-end collision with a total Delta-V of 28.5 mph (CISS Case No. 1-33-2019-020-05)

Figure 6: Photographic reproductions of a 1994 Chevrolet pickup truck involved in a front-end collision with a total Delta-V of 26.7 mph (NASS Case No. 2004-43-176)

Figure 7: Photographic reproductions of a 1993 Chevrolet pickup truck involved in a front-end collision with a total Delta-V of 26.7 mph (NASS Case No. 2004-47-043)

Figure 8: Photographic reproductions of a 1995 Chevrolet pickup truck involved in a front-end collision with a total Delta-V of 23.6 mph (NASS Case No. 2004-12-110)

Kinematic Analysis:

The available documents reported Mr. Norman was 58 years of age, 69 inches tall, and weighed approximately 190 pounds, and was wearing the available three-point restraint at the time of the subject incident. During his testimony, Mr. Norman stated the incident Jeep entered his lane approximately one-to-two seconds prior to impact. He was facing straight forward, put his arms up in an 'X' in front of his face, and braked (but does not recall if the brakes locked). Due to the impact, Mr. Norman's, "*chest and torso and low back were impacted by the seat belt as I compressed against them, and I believe my head went back, and – but I had the headrest*". He testified he lost consciousness; specifically, "*I was in a conscious state of being, not a physical state of being. So again, I'm assuming that's – that's a blackout*". He also didn't remember striking his head on anything inside the vehicle. When asked about the subject Chevrolet's broken rear window, he stated "*it wouldn't have been my head physically. It would have been the seat*". The reporting officer noted in the Investigator's Traffic Crash Report "*all of the occupants stated that they were not injured*". Narratives in the available medical records from Mr. Norman's emergency room visit on February 14, 2017 state "*he does not believe he had [loss of consciousness], but did break the window with his head*".

Using the fundamental laws of physics, as well as studies of numerous collisions and crash tests, the subject Chevrolet's occupant kinematic patterns can be determined.[33,34,35,36,37] The laws of physics dictate that, when contact occurred between the incident Jeep and the front of the subject Chevrolet, the subject Chevrolet would have decelerated longitudinally. This process would have resulted in primarily forward motion of Mr. Norman relative to the interior of his vehicle. As the forces were applied during the vehicle contact, the belt retractor would have locked when the

33 National Highway Traffic Safety Administration New Car Assessment Program (NCAP) Frontal Barrier Impact Test. 1988 Chevrolet C1500 Pickup, Report No. MJ0100, March 31, 1988.

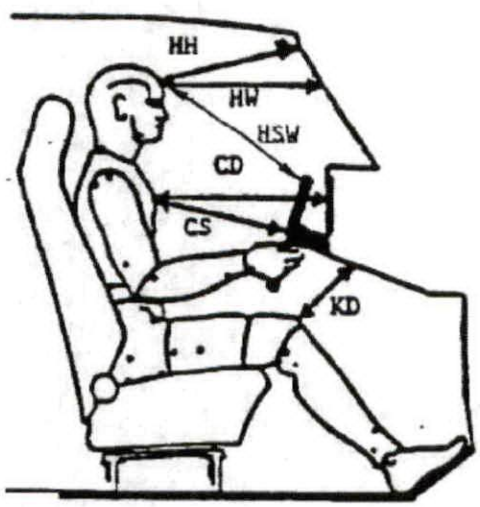
34 National Highway Traffic Safety Administration Vehicle Safety Compliance Testing for Occupant Crash Protection. 1992 Chevrolet Fleetside C1500 Pickup Truck, Report No. CN0112, February 4, 1992.

35 Arbogast, K.B., Balasubramanian, S., Seacrist, T., et al., (2009). Comparison of Kinematic Response of the Head and Spine for Children and Adults in Low-Speed Frontal Sled Tests (SAE 2009-22-0012). Warrendale, PA, Society of Automotive Engineers.

36 Tornvall, F.V., Svensson, M.Y., Davidsson, J., et al. (2005). Frontal Impact Dummy Kinematics in Oblique Frontal Collisions: Evaluation Against Post Mortem Human Subject Test Data. *Traffic Injury Prevention* 6: 340-350.

37 Toney-Bolger, M., Campbell, I., Miller, B., et al. (2019). Evaluation of Occupant Loading in Low- to Moderate-Speed Frontal and Rear-End Motor Vehicle Collisions (SAE 2019-01-1220). Society of Automotive Engineers. Warrendale, PA.

accelerations exceeded 0.7g, thereby mitigating the forward motion of the occupants.[38] The lap and shoulder belts would have restrained Mr. Norman's pelvis and torso, respectively, and would have coupled his motion to the subject Chevrolet. The seat belt would have distributed the restraint loads to strong bony structures, such as his left clavicle and pelvis. A kinematic analysis performed in the context of the vehicle specific interior further indicated that Mr. Norman would not have experienced any substantial impact against the interior structures of the vehicle, consistent with his testimony (Figure 9).[39,40,41,42,43] These data demonstrate that Mr. Norman's response to the collision was limited and well controlled by the occupant protection system.



	Driver
HH	18.0
HW	22.0
CD	21.6
CS	11.2
KD L-	7.5
KD R-	7.6
Torso Angle	21.0
Seat Back Angle	21.0
HSW	13.5

38 Federal Motor Vehicle Safety Standard 209: Seat Belt Assemblies, 49 CFR 571.209.

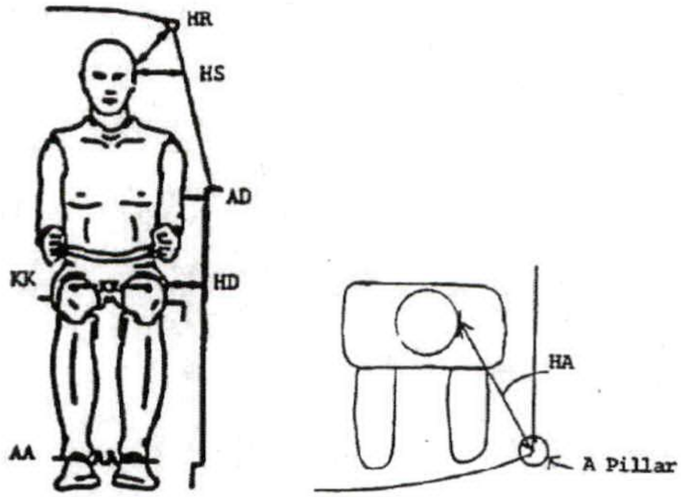
39 Araszewski, M., Toor, A, and Happer, A. (2001). Knee and Hip Displacements of Vehicle Occupants Restrained by Seat Belts in Frontal Impacts (SAE 2001-01-0180). Society of Automotive Engineers. Warrendale, PA.

40 Araszewski, M., and Toor, A. (2003). Head, Hip and Knee Velocities of Restrained Occupants in Frontal Impacts (SAE 2003-01-0884). Society of Automotive Engineers. Warrendale, PA.

41 Araszewski, M., Roenitz, E., Toor, A. (1999). Maximum Head Displacement of Vehicle Occupants Restrained by Lap and Torso Seat Belts in Frontal Impacts (SAE 1999-01-0443). Society of Automotive Engineers. Warrendale, PA.

42 Happer, A., Hughes, M., Simeonovic, G., et al (2004). Occupant Displacement Model for Restrained Adults in Vehicle Frontal Impacts (SAE 2004-01-1198). Warrendale, PA. Society of Automotive Engineers.

43 National Highway Traffic Safety Administration New Car Assessment Program (NCAP) Frontal Barrier Impact Test. 1988 Chevrolet C1500 Pickup, Report No. MJ0100, March 31, 1988.



	Driver
HR	10.0
HS	11.2
AD	7.1
HD	8.4
KK	14.5
AA	10.0
HA	23.0

Figure 9: Interior clearances of a 1988 Chevrolet pickup truck (dimensions are in inches)

Evaluation of Biomechanical Failure Mechanisms:

Based upon the review of the damage to the subject vehicle and the available incident data, the relevant crash severity resulted in accelerations well within the limits of human tolerance. Without exceeding these limits, or the normal range of motion, there is no biomechanical failure mechanism present to causally link his reported biomechanical failures and the subject incident.[44,45]

From a biomechanical perspective, causation between an alleged incident and a claimed biomechanical failure is determined by addressing two issues or questions:

1. Did the subject incident load the body in a manner known to cause damage to a body part? That is, did the subject event create a known biomechanical failure mechanism?
2. If a biomechanical failure mechanism was present, did the subject event load the body with sufficient magnitude to exceed the tolerance or strength of the specific body part? That is, did the event create a force sufficiently large to cause damage to the tissue?

If both the biomechanical failure mechanism was present and the applied loads approached or exceeded the tolerance of the body part, then a causal relationship between the subject incident and the claimed biomechanical failures cannot be ruled out. If, however, the biomechanical failure mechanism was not present or the applied loads were small compared to the strength of the effected tissue, then a causal relationship between the subject incident and the biomechanical failures cannot be made.

Post-Concussion Syndrome

During his emergency room visit on February 14, 2017, 11 days after the subject incident, Mr. Norman was diagnosed with post-concussion syndrome. As stated previously, the medical records reported no loss of consciousness. A concussion is classically defined by a brief disturbance of neural function induced by a sudden acceleration of the head, typically without skull fracture.[46,47]

44 Mertz, H.J. and Patrick, L.M. (1967). *Investigation of The Kinematics and Kinetics of Whiplash*. (No. 670919). SAE Technical Paper.
45 Mertz, H.J. and Patrick, L.M. (1971). *Strength and Response of The Human Neck*. (No. 710855). SAE Technical Paper.
46 Shaw, N. A. (2002). The Neurophysiology of concussion. *Progress in Neurobiology* 67: 281-344.
47 Gennarelli, T.A., (2003) "Mechanisms of Brain Injury." Journal of Emergency Medicine 11: 5-11.

Acute onset of concussion is associated with substantial impulsive or impact loads applied to the head.[48]

Linear accelerations are measured in units of distance (i.e., feet) per second squared (often normalized, as herein, by gravitational acceleration "g"), whereas rotational accelerations are most commonly reported as radians per second squared (rad/sec^2). It has been suggested that either type of acceleration, or combinations thereof, at specific magnitudes can produce concussions of varying severity. Gennarelli et al. synthesized a number of studies and described diffuse brain trauma as a continuous spectrum spanning from mild, classical, and severe concussions to considerably more severe trauma.[49] Mild concussions were defined as those that do not involve loss of consciousness and were associated with rotational accelerations of 2,878 rad/sec^2, whereas classical concussions were defined as those that involve loss of consciousness for less than 1 hour, and were associated with rotational acceleration thresholds of in the range of 4,500-5,756 rad/sec^2. More recently, Rowson and Duma reported a combined probability of concussion based upon both peak linear and peak rotational accelerations of the head.[50] They reported thresholds of linear accelerations at 120 g and rotational accelerations even greater than those described by Gennarelli et al. These findings were also largely consistent with extensive prior research conducted by Ono et al.[51]

The Head Injury Criterion (HIC) has been adopted by the United States federal government as the standard criterion for the determination of risk of brain trauma for the Federal Motor Vehicle Safety Standards (FMVSS). In brief, HIC is calculated from resultant accelerations at the center of gravity of the head over a specified duration. FMVSS 201, titled Occupant Protection in Interior Impact, specifies requirements to afford impact protection for occupants.[52] FMVSS 201 dictates that when the interior of a vehicle is impacted by a free-motion Hybrid III headform at a speed of 15 miles per hour, the measured HIC of the anthropomorphic test device should not exceed 1,000 for any two points in time during the impact which are separated by not more than a 36 millisecond time interval.

As described previously, Mr. Norman's body would have moved forward relative to the subject vehicle's interior. The three-point restraint he was wearing would have limited this motion. During this response, Mr. Norman's head would have been subjected to some degree of forward flexion upon impact. Based upon my engineering analyses and associated evaluations of the severity of the subject incident, Mr. Norman's head would have experienced peak accelerations of approximately 30g and 1,700 rad/sec^2 during the collision with the incident Jeep. Testing with anthropomorphic test devices have quantified head accelerations during frontal impacts at severities similar to the subject incident.[53,54] Occupants in the driver's seat experienced peak head

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48 Goldsmith, W., (2001) "The State of Head Injury Biomechanics: Past, Present, and Future: Part 1." Critical Reviews in Biomedical Engineering 29 (5 & 6): 441-600.

49 Gennarelli, T.A., Pintar, F.A., Yoganandan, N. (2003). Biomechanical Tolerances for Diffuse Brain Injury and a Hypothesis for Genotypic Variability in Response to Trauma. 47th Annual Proceedings – Association for the Advancement of Automotive Medicine.

50 Rowson, S. and Duma, S.M. (2013) Brain Injury Prediction: Assessing the Combined Probability of Concussion Using Linear and Rotational Head Acceleration. *Annals of Biomedical Engineering* **41(5)**: 873-882.

51 Ono, K., Kikuchi, A., et al. (1980). Human Head Tolerance to Sagittal Impact Reliable Estimation Deduced from Experimental Head Injury Using Subhuman Primates and Human Cadaver Skulls. (SAE 801303). Warrendale, PA, Society of Automotive Engineers.

52 Federal Motor Vehicle Safety Standard 201. Occupant Protection in Interior Impact. 49 CFR 571.201.

53 National Highway Traffic Safety Administration New Car Assessment Program (NCAP) Frontal Barrier Impact Test. 1988 Chevrolet C1500 Pickup, Report No. MJ0100, March 31, 1988.

54 National Highway Traffic Safety Administration Vehicle Safety Compliance Testing for Occupant Crash Protection. 1992 Chevrolet Fleetside C1500 Pickup Truck, Report No. CN0112, February 4, 1992.

accelerations between 140 and 300g, equating to a HIC of 500 to 900. Thus, the subject incident lacked the energy necessary to create a mechanism for a causal relationship for Mr. Norman's post-concussion syndrome.[55,56]

Approximately seven months after the subject motor vehicle collision, on August 28, 2017, Mr. Norman went to the emergency room after being struck in the head by a steel post driver. According to his deposition testimony, Mr. Norman was performing fence-work on his own property with a colleague, Mr. Erik Rodgers. Mr. Rodgers was on a ladder operating the post driver 10 feet in the air, as Mr. Norman kneeled on the ground holding the post, when the post driver slipped out of Mr. Rodger's hands, fell, and struck Mr. Norman on the top of his head. For comparison, an exemplar post driver weights approximately 20 pounds, noted as Exhibit 2 in Mr. Norman's 2022 deposition. The emergency room records noted a ¾-inch skull divot and 2-inch laceration on Mr. Norman's scalp vertex which required staples. There are mixed accounts in the available medical records whether Mr. Norman lost consciousness, although Mr. Norman testified he did not lose consciousness.

Research at ARCCA, Inc. has conducted tests with objects striking the head and quantified resulting head accelerations. This testing demonstrates the head accelerations Mr. Norman experienced during the post driver incident substantially exceeded those of the subject motor vehicle collision. An object falling 8 feet will reach an approximate speed of 15 mph. ARCCA testing of a 5-pound object striking the head at less than 7 mph indicated that linear head accelerations can exceed 120 g and rotational accelerations can exceed 4,500 rad/sec^2. As noted above, these values exceed accepted thresholds for concussion. Testing of objects approximating the weight of the post driver indicated similar values that exceed accepted thresholds.

Based upon the review of the available incident data and the results cited in the technical literature as described above, the kinematics or occupant motions caused by the subject motor vehicle collision were well below established head trauma thresholds and within the normal range of head accelerations. As such, a causal link between the subject incident and the attributed post-concussion syndrome cannot be made.

It is important to note that the peer-reviewed and generally-accepted technical articles cited throughout this report are included as support for the methodologies employed and the conclusions developed through my independent analysis of the subject incident. These scientific studies were not cited to simply be extrapolated to the subject incident and provide general opinions regarding the likelihood of occupant biomechanical failure following a motor vehicle incident. My conclusions are specific to the characteristics of the subject incident. My analysis incorporated thorough analyses of the incident severity, occupant response, biomechanical failure mechanisms, and an understanding of the unique personal tolerance levels of Mr. Norman. My evaluation regarding the lack of a causal relationship between Mr. Norman's reported biomechanical failures and the subject incident was reached using peer-reviewed and generally-accepted methodologies.

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55 Yoganandan, N., Gennarelli, T.A., et al., (2009) "Association of Contact Loading in Diffuse Axonal Injuries from Motor Vehicle Crashes." Journal of Trauma 66(2): 309-315.

56 Mclean, A.J., (1995) "Brain Injury without Head Impact?" Journal of Neurotrauma 12(4): 621-625.

ARCCA INCORPORATED

Conclusions:

Based upon a reasonable degree of scientific and biomechanical certainty, on a more probable than not basis, I conclude the following:

1. On February 3, 2017, Mr. Norman was the seat-belted driver of a 1989 Chevrolet C2500 traveling eastbound on Highway 101 in Port Angeles, Washington, when contact occurred between the right side of the incident 2012 Jeep Liberty and the front of the subject Chevrolet.
2. The severity of the subject incident was less than 30 miles-per-hour with an average acceleration of less than 13.7g for the subject Chevrolet.
3. Mr. Norman would have moved primarily forward relative to the interior of the subject vehicle. These motions would have been limited and well controlled by the three-point restraint system and seat structures.
4. There is no biomechanical failure mechanism present in the subject incident to account for Mr. Norman's claimed head biomechanical failures. As such, a causal relationship between the subject incident and the head biomechanical failures cannot be made.
5. An analysis of the potential head forces and rotations associated with contact from a falling post driver indicates that accepted thresholds for head/brain biomechanical failures are exceeded.

I, Bradley Probst, declare under penalty of perjury under the laws of the State of Washington that the preceding is true and correct. I am over the age of 18 years, I am competent to testify, and I have personal knowledge of the facts contained herein in this report. I declare that this report was prepared by myself and is true and correct to the best of my knowledge. The opinions and conclusions stated herein are stated on a more probable than not basis and to a reasonable degree of engineering certainty.

If you have any questions, require additional assistance, or if any additional information becomes available, please do not hesitate to call.

This preliminary analysis is intended for use by the addressee, who assumes sole responsibility for any dissemination of this document.

Sincerely,

Bradley W. Probst, MSBME

Director of Biomechanics & Human Factors – West Coast, V.P.